



Taxonomic paper

Studies in Hawaiian Diptera I: New Distributional Records for Endemic *Asteia* (Asteiidae)

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Abstract

New island records are reported for five species of *Asteia* endemic to the Hawaiian Islands (*A. hawaiiensis*, *A. mauiensis*, *A. molokaiensis*, *A. palikuensis*, *A. sabroskyi*). These new records expand our understanding of distributions in *Asteia*, change the percentage of single island endemics from 78% to 33%, and have significance in how we view the process of diversification acting in this lineage. We also present a list of the known rearing records for two species in this group. *Asteia montgomeryi* has been recorded from *Erythrina* and *A. sabroskyi* has been reared from *Pisonia*, *Urera*, *Charpentiera* and *Hibiscadelphus*.

Keywords

Hawaiian Islands, Diptera, Asteiidae, *Asteia*, distributions, new island records

Introduction

Research on the Diptera of the Hawaiian Islands dates to the last half of the 19th century and was first summarized in the *Fauna Hawaiiensis* (1899-1910) series (Sharp 1899).

Zimmerman's multivolume Insects of Hawaii series (1948-2003) has also added greatly to our knowledge of the endemic and introduced insect species present in Hawaii (Zimmerman 1948). The Proceedings of the Hawaiian Entomological Society and the Records of the B. P. Bishop Museum are two other venues that were used by Hawaiian entomologists to publish shorter works or updates on new species, new invaders or new island records. It was from these works that the Bishop Museum created a comprehensive checklist of the Terrestrial Arthropods of the Hawaiian Islands (Nishida 2002). My lab has been conducting collections and surveys in Hawaii as part of various projects for over 15 years. As a result, we have many new species and new island records and have generated a number of new identification tools for several fly families. The goal of this multipart series is to publish these data in an accessible format to facilitate further research on Hawaiian Diptera. Future papers will focus on new island records and identification tools for *Dicranomyia*, a description of a new species of *Procانcae* with a revised key to the genus, and new island records for *Scatella*.

Asteiidae are a small family of acalyprate flies, containing approximately 130 species worldwide. There are 11 genera in the family but over half of the described species belong to a single genus, *Asteia* (Sabrosky 1956, Sabrosky 1957, Sabrosky 1987). The ecological associations of this group are unclear, although members of this family have been reared from a variety of substrates, including fungi, frass, bleeding trees and dried stems (Sabrosky 1987).

The most recent revision of the Hawaiian Asteiidae (Hardy and Delfinado 1980), lists three genera, *Asteia*, *Bryania*, and *Loewimyia*, as well as a comprehensive key to Hawaiian members of this family. *Bryania* and *Loewimyia* each contain a single species from Hawaii and are uncommon in collections. Hardy and Delfinado (1980) considered *Bryania bipunctata*, the only species described in this genus, an endemic species from the Northwest Hawaiian Islands. The relationship of *Bryania* to the other Hawaiian asteiids remains unclear. They described *Loewimyia orbiculata* as a new species from Oahu but did not comment on whether or not they considered it to be endemic (Hardy and Delfinado 1980). The genus *Loewimyia* is known only from one other species found only in North America so it may be a migrant. Members of the genus *Asteia* are the largest and most commonly collected asteiids, comprising nine of the eleven Hawaiian asteiid species (Table 1).

Table 1.

Distribution of *Asteia* species in Hawaii. Status indicates whether the species are endemic (E), introduced (I) or adventive (A). Islands sampled are: Kauai (K), Oahu (O), Molokai (Mo), Lanai (L), Maui (Ma), and Hawaii (H). Presence of a species on a given island is designated by an X. An asterisk denotes a new island record for the species.

Species	Status	NWHI	K	O	Mo	L	Ma	H
<i>A.aberrans</i>	E	X						
<i>A.apicalis</i>	E					X	X	
<i>A.hawaiensis</i>	E					X*	X	

<i>A.mauiensis</i>	E			X*			X
<i>A.molokaiensis</i>	E				X	X*	X*
<i>A.montgomeryi</i>	E						X
<i>A.nudiseta</i>	E			X			
<i>A.palikuensis</i>	E				X*	X	X*
<i>A.sabroskyi</i>	E		X	X	X	X	X*

Many Hawaiian radiations are characterized by a high degree of single island endemism. For example, >95% of the ~300 species Hawaiian *Campsicnemus* (Diptera: Dolichopodidae) are single island endemics (Evenhuis 2008) and approximately 85% of the 1000 Hawaiian *Drosophila* (Diptera: Drosophilidae) are also found on just one island (Evenhuis 2008, O'Grady et al. 2009). In contrast, smaller groups like the genus *Dicranomyia* (Diptera: Limoniidae) have less than 30% of species endemic to a single island (Nitta and O'Grady 2008, Goodman and O'Grady 2013). According to the latest revision of the Hawaiian *Asteia* (Hardy and Delfinado 1980), seven of the nine described species (78%) are single island endemics. However, recent collections demonstrate that only three of the nine (33%) known species are endemic to a single island (Table 1).

Materials and methods

Literature Review

We have reviewed the literature for the Hawaiian *Asteia* and have attempted to include information on both the taxonomic history of the species and all occurrences of the endemic taxa in the literature, including the original descriptions, subsequent revisions, additional descriptive notes, range expansions and new island records and catalogs. The original authors of most of the species covered here designated holotypes, allotypes and paratypes in the original descriptions. We list the type, paratypes and other material examined. We have attempted to include as much collection data from the original publications as possible. In some cases label data were elaborated via examination of material deposited in the B. P. Bishop Museum or the University of Hawaii Entomological Collection.

Collection Methods

All material was obtained from general sweeping of vegetation, seeps and streams. Samples were preserved in 95% ethanol (ETOH) and transported to UC Berkeley for identification. Key and descriptions by Hardy and Delfinado (1980) were used to identify the Hawaiian *Asteia*. Historical specimens examined in this study are deposited in the University of Hawaii Entomology Collection (UHEC) or the B. P. Bishop Museum (BPBM). All material collected by the authors was preserved in 95% ETOH and deposited in the University of California's Essig Museum of Entomology (UCB).

Checklist of Hawaiian *Asteia* (Diptera: Asteiidae)

Asteia aberrans Hardy & Delfinado, 1980

Nomenclature: *Asteia aberrans* Hardy & Delfinado, 1980: 233

Materials

Holotype:

- a. islandGroup: Hawaiian Islands; island: Northwest Hawaiian Islands; verbatimLocality: Nihoa; verbatimEventDate: 23-24.ix.1964; individualCount: 1; sex: female; recordedBy: JW Beardsley; institutionCode: BPBM

Paratypes:

- a. islandGroup: Hawaiian Islands; island: Northwest Hawaiian Islands; verbatimLocality: Nihoa; verbatimEventDate: 23-24.ix.1964; individualCount: 2; sex: female; recordedBy: JW Beardsley; institutionCode: BPBM
- b. islandGroup: Hawaiian Islands; island: Northwest Hawaiian Islands; verbatimLocality: Necker; verbatimEventDate: 26-27.ix.1964; individualCount: 1; sex: male; institutionCode: UHEC

Other materials:

- a. islandGroup: Hawaiian Islands; island: Northwest Hawaiian Islands; verbatimLocality: Nihoa, E Palm Valley, in moist shelter cave; verbatimElevation: 150m; eventDate: 27.iv.1983; individualCount: 4; recordedBy: WC Gagne; collectionID: 1983.184; institutionCode: BPBM
- b. islandGroup: Hawaiian Islands; island: Northwest Hawaiian Islands; verbatimLocality: Nihoa, Miller V, yellow pan trap in low shrubs; verbatimElevation: 100 ft; eventDate: 22.vi.1990; individualCount: 1; recordedBy: J. Strazanac; institutionCode: BPBM

Native status: endemic

Distribution: HAWAIIAN ISLANDS: Northwest Hawaiian Islands (Necker, Nihoa)

Notes: Hardy and Delfinado (1980) [original description; illustration of male genitalia (right lateral), head (lateral), wing]; Sabrosky (1989) [Australasian and Oceanian Catalog]; Nishida (2002) [Hawaiian Terrestrial Arthropod Checklist]; Evenhuis (2011) [<http://hbs.bishopmuseum.org/aocat/asteiidae.html>, Australasian and Oceanian Catalog, online version].

***Asteia apicalis* Grimshaw, 1901**

Nomenclature: *Asteia apicalis* Grimshaw, 1901: 73

Materials

Holotype:

- a. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Kilauea; verbatimEventDate: vii.1895; individualCount: 1; sex: male; recordedBy: no collector given; institutionCode: BMNH

Paratype:

- a. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Kilauea; verbatimEventDate: vii.1895; individualCount: 3; sex: male; recordedBy: no collector given; institutionCode: BMNH

Other materials:

- a. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Kilauea; eventDate: 27.vi.1917; individualCount: 1; recordedBy: OH Swezey; identifiedBy: DE Hardy; institutionCode: BPBM
- b. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Upper Hamakua Ditch Trail; eventDate: 3.ix.1919; individualCount: 1; recordedBy: OH Swezey; identifiedBy: DE Hardy; institutionCode: BPBM
- c. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Upper Hamakua Ditch Trail; eventDate: 1-7.x.1929; individualCount: 5; recordedBy: OH Swezey; identifiedBy: DE Hardy; institutionCode: BPBM
- d. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Kilauea, Hawaii National Park; verbatimEventDate: viii.1946; sex: female; recordedBy: WW Wirth, CJ Davis; institutionCode: USNM
- e. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Kilauea, Hawaii National Park; verbatimEventDate: ix.1946; sex: female; recordedBy: WW Wirth, CJ Davis; institutionCode: USNM
- f. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Kilauea, light trap; eventDate: viii.1958; individualCount: 1; recordedBy: JW Beardsley; institutionCode: BPBM
- g. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Kilauea For. Res. IPB Study Site; verbatimElevation: 1586 m; eventDate: 2.vii.1971; individualCount: 28; recordedBy: FG Howarth; identifiedBy: DE Hardy; institutionCode: BPBM
- h. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Kaupo Trail, Haleakala National Park, on and under Acacia koa; verbatimElevation: 5500 ft; verbatimEventDate: 2.viii.2007; individualCount: 2; recordedBy: KN Magnacca; identifiedBy: PM O'Grady; institutionID: EMEC7356000; institutionCode: EMEC; collectionCode: 07-0735
- i. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Kau; verbatimElevation: 4000 ft; eventDate: no date given; individualCount: 1; recordedBy: no collector given; identifiedBy: DE Hardy; institutionCode: BPBM

Native status: endemic

Distribution: HAWAIIAN ISLANDS: Maui, Hawaii

Notes: Grimshaw (1901) [original description]; Sabrosky (1947) [redescription]; Hardy and Delfinado (1980) [redescription; illustration of male genitalia (terminal), male

genitalia (right lateral), antenna (lateral)]; Sabrosky (1989) [Australasian and Oceanian Catalog]; Nishida (2002) [Hawaiian Terrestrial Arthropod Checklist]; Evenhuis (2011) [<http://hbs.bishopmuseum.org/aocat/asteiidae.html>, Australasian and Oceanian Catalog, online version].

***Asteia hawaiiensis* Grimshaw, 1901**

Nomenclature: *Asteia hawaiiensis* Grimshaw, 1901: 73

Materials

Holotype:

- a. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Kona; verbatimElevation: 3500-400 ft; verbatimEventDate: vi-vii.1892; individualCount: 1; sex: male; recordedBy: no collector given; institutionCode: BMNH

Paratypes:

- a. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Kona; verbatimElevation: 3500-400 ft; verbatimEventDate: vi-vii.1892; individualCount: 4; recordedBy: no collector given; institutionCode: BMNH
- b. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Olaa; verbatimEventDate: xi.1896; individualCount: 1; sex: female; recordedBy: no collector given; institutionCode: BMNH

Other materials:

- a. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Glenwood; eventDate: 3.ii.1919; individualCount: 1; recordedBy: OH Swezey; identifiedBy: EH Bryan; institutionCode: BPBM
- b. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: S. Kona; eventDate: 8-20.viii.1919; individualCount: 11; recordedBy: OH Swezey; identifiedBy: EH Bryan; institutionCode: BPBM
- c. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Olaa Forest; verbatimElevation: 3200 ft; eventDate: 22.vi.1985; individualCount: 6; recordedBy: WC Gagne, W. Mull; identifiedBy: K Arakaki; institutionCode: BPBM
- d. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Puu Kukui, Kahanaiki Gulch, sweeping veg and ground; verbatimElevation: 2100 ft; verbatimEventDate: 7.viii.2007; individualCount: 1; recordedBy: KN Magnacca; identifiedBy: PM O'Grady; institutionID: EMEC7356001; institutionCode: EMEC; collectionCode: 07-0813
- e. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Kau; verbatimElevation: 4000 ft; eventDate: no date given; individualCount: 1; recordedBy: no collector given; identifiedBy: EH Bryan; institutionCode: BPBM

Native status: endemic

Distribution: HAWAIIAN ISLANDS: Maui, Hawaii

Notes: Grimshaw (1901) [original description]; Hardy and Delfinado (1980) [redescription; illustration of whole fly (lateral), wing, antenna (lateral), male genitalia (left lateral)]; Sabrosky (1989) [Australasian and Oceanian Catalog]; Nishida (2002) [Hawaiian Terrestrial Arthropod Checklist]; Evenhuis (2011) [<http://hbs.bishopmuseum.org/aocat/asteiidae.html>]

hbs.bishopmuseum.org/aocat/asteiidae.html, Australasian and Oceanian Catalog, online version].

***Asteia mauiensis* Hardy & Delfinado, 1980**

Nomenclature: *Asteia mauiensis* Hardy & Delfinado, 1980: 238

Materials

Holotype:

- a. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Waikamoi; verbatimElevation: 4000 ft; verbatimEventDate: vii.1956; individualCount: 1; sex: female; recordedBy: R Namba; institutionCode: BPBM

Paratypes:

- a. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Waikamoi; verbatimElevation: 4000 ft; verbatimEventDate: i.1926-vii.1965; individualCount: 4; recordedBy: OH Swezey, HT Spieth, R Namba, DE Hardy; institutionCode: UHEC
- b. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Iao Valley; verbatimElevation: 1500 ft; verbatimEventDate: vi.1952; individualCount: 1; sex: female; recordedBy: DE Hardy; institutionCode: UHEC
- c. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Puu Kukui; verbatimEventDate: vii.1963; individualCount: 3; recordedBy: CR Joyce; institutionCode: USNM
- d. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Waikamoi; verbatimElevation: 4000 ft; verbatimEventDate: 6.vii.1966; individualCount: 1; sex: male; recordedBy: DE Hardy; institutionCode: BPBM

Other materials:

- a. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Kaupo Trail, Haleakala National Park, sweeping Lobelia hypoleuca; verbatimElevation: 6100 ft; verbatimEventDate: 2.viii.2007; individualCount: 2; recordedBy: KN Magnacca; identifiedBy: PM O'Grady; institutionID: EMEC7356002; institutionCode: EMEC; collectionCode: 07-0726
- b. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Heed Trail, Waikamoi Forest Preserve; verbatimEventDate: 31.vii.2007; individualCount: 1; recordedBy: PM O'Grady, KN Magnacca, RT Lapoint, GM Bennett; identifiedBy: PM O'Grady; institutionID: EMEC7356003; institutionCode: EMEC; collectionCode: 389
- c. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Makapuu Stream; verbatimEventDate: viii.2009; individualCount: 1; recordedBy: GM Bennett; identifiedBy: PM O'Grady; institutionID: EMEC7356004; institutionCode: EMEC; collectionCode: 545.L

Native status: endemic

Distribution: HAWAIIAN ISLANDS: Oahu, Maui

Notes: Hardy and Delfinado (1980) [original description; illustration of female abdomen (lateral), female abdomen (lateral), male genitalia (left lateral)]; Sabrosky (1989) [Australasian and Oceanian Catalog]; Nishida (2002) [Hawaiian Terrestrial Arthropod Checklist]; Evenhuis (2011) [<http://hbs.bishopmuseum.org/aocat/asteiidae.html>, Australasian and Oceanian Catalog, online version].

***Asteia molokaiensis* Hardy & Delfinado, 1980**

Nomenclature: *Asteia molokaiensis* Hardy & Delfinado, 1980: 238

Materials

Holotype:

- a. islandGroup: Hawaiian Islands; island: Molokai; verbatimLocality: Puu Kolekole; verbatimElevation: 3600 ft; verbatimEventDate: 20.vii.1964; individualCount: 1; sex: female; recordedBy: D Gubler; institutionCode: BPBM

Paratype:

- a. islandGroup: Hawaiian Islands; island: Molokai; verbatimLocality: Puu Kolekole; verbatimElevation: 3600 ft; verbatimEventDate: vi.1952-viii.1964; individualCount: 4; sex: female; recordedBy: DE Hardy, M Tamashiro; institutionCode: UHEC

Other materials:

- a. islandGroup: Hawaiian Islands; island: Lanai; verbatimLocality: Lanaihale; verbatimElevation: 914 m; eventDate: 20.v.1980; individualCount: 1; sex: female; recordedBy: BH Gagne; identifiedBy: K Arakaki; institutionCode: BPBM
- b. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Kaupo Trail, Haleakala National Park, sweeping veg and ground; verbatimElevation: 5500 ft; verbatimEventDate: 2.viii.2007; individualCount: 1; recordedBy: KN Magnacca; identifiedBy: PM O'Grady; institutionID: EMEC7356005; institutionCode: EMEC; collectionCode: 07-0755
- c. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Makawao Forest Reserve, on and under Clermontia; verbatimElevation: 4500 ft; verbatimEventDate: 6.viii.2007; individualCount: 1; recordedBy: KN Magnacca; identifiedBy: PM O'Grady; institutionID: EMEC7356006; institutionCode: EMEC; collectionCode: 07-0808

Native status: endemic

Distribution: HAWAIIAN ISLANDS: Molokai, Maui

Notes: Hardy and Delfinado (1980) [original description; illustration of female abdomen (lateral)]; Sabrosky (1989) [Australasian and Oceanian Catalog]; Nishida (2002) [Hawaiian Terrestrial Arthropod Checklist]; Evenhuis (2011) [<http://hbs.bishopmuseum.org/aocat/asteiidae.html>, Australasian and Oceanian Catalog, online version].

***Asteia montgomeryi* Hardy, 1980**

Nomenclature: *Asteia montgomeryi* Hardy, 1980: 239

Materials

Holotype:

- a. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Puuwaawaa; verbatimElevation: 2000 ft; verbatimEventDate: 16.ii.1973; individualCount: 1; sex: male; recordedBy: WB Heed; institutionCode: BPBM

Paratype:

- a. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Puuwaawaa; verbatimElevation: 2000 ft; verbatimEventDate: 16.ii.1973; individualCount: 1; sex: male; recordedBy: WB Heed; institutionCode: UHEC

Feeds on: This species has been reared from rotting stems of *Erythrina sandwichensis* Degener (Hawaiian Islands: Hawaii, Puuwaawaa, 2000 ft., WB Heed and SL Montgmyer, iv-vi.1973)

Native status: endemic

Distribution: HAWAIIAN ISLANDS: Hawaii

Notes: Hardy and Delfinado (1980) [original description; illustration of male genitalia (terminal), antenna (lateral)]; Sabrosky (1989) [Australasian and Oceanian Catalog]; Nishida (2002) [Hawaiian Terrestrial Arthropod Checklist]; Evenhuis (2011) [<http://hbs.bishopmuseum.org/aocat/asteiidae.html>, Australasian and Oceanian Catalog, online version].

Asteia nudiseta Sabrosky, 1947

Nomenclature: *Asteia nudiseta* Sabrosky, 1947: 55

Materials

Holotype:

- a. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Mt. Kaala, bog at summit; verbatimElevation: 4000 ft; verbatimEventDate: iv.1892; individualCount: 1; sex: female; recordedBy: WW Wirth; institutionID: 58218; institutionCode: USNM

Other materials:

- a. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Haleauau, Suttonia; eventDate: 13.iii.1932; individualCount: 1; recordedBy: OH Swezey; identifiedBy: DE Hardy; institutionCode: BPBM
- b. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Puu Kanehoa, at light; eventDate: 10.viii.1959; individualCount: 6; recordedBy: JW Beardsley; identifiedBy: DE Hardy; institutionCode: BPBM
- c. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Mt. Kaala summit, ex Melicope; eventDate: 13.vi.1994; individualCount: 5; recordedBy: A Asquith; identifiedBy: K Arakaki; institutionCode: BPBM

Paratype:

- a. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Oahu; verbatimEventDate: no date given; individualCount: 1; sex: female; recordedBy: JC Bridwell; institutionCode: USNM

Native status: endemic

Distribution: HAWAIIAN ISLANDS: Oahu

Notes: Sabrosky (1947) [original description]; Hardy and Delfinado (1980) [redescription; illustration of female abdomen (lateral), antenna (lateral), male genitalia (left lateral)]; Sabrosky (1989) [Australasian and Oceanian Catalog]; Nishida (2002) [Hawaiian Terrestrial Arthropod Checklist]; <http://hbs.bishopmuseum.org/aocat/asteiidae.html>; Evenhuis and Eldredge (2004); Evenhuis (2011) [<http://hbs.bishopmuseum.org/aocat/asteiidae.html>, Australasian and Oceanian Catalog, online version].

***Asteia palikuensis* Hardy & Delfinado, 1980**

Nomenclature: *Asteia palikuensis* Hardy & Delfinado, 1980: 242

Materials

Holotype:

- a. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Paliku, Haleakala Crater; verbatimElevation: 6500 ft; verbatimEventDate: 28.vii.1964; individualCount: 1; sex: male; recordedBy: LH Throckmorton; institutionCode: BPBM

Paratypes:

- a. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Paliku, Haleakala Crater; verbatimElevation: 6500 ft; verbatimEventDate: vi.1952-viii.1965; individualCount: 158; recordedBy: DE Hardy, CR Joyce, D Gubler, JW Beardsley, LH Throckmorton, M Tamashiro; institutionCode: UHEC
- b. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Holua; verbatimElevation: 6500 ft; verbatimEventDate: vi.1953; recordedBy: DE Hardy; institutionCode: USNM, BMNH
- c. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Paliku, Haleakala Crater; verbatimElevation: 6500 ft; verbatimEventDate: 28.vii.1964; individualCount: 1; sex: female; recordedBy: LH Throckmorton; institutionCode: BPBM
- d. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Kaupo Trail; verbatimElevation: 5500 - 6500 ft; verbatimEventDate: 22.vii.1965; recordedBy: JW Beardsley; institutionCode: USNM, BMNH
- e. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Oili Puu; verbatimEventDate: 23.vii.1965; recordedBy: JW Beardsley; institutionCode: USNM, BMNH

Other materials:

- a. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Kilauea For. Res. IBP Malaise Trap #2; verbatimElevation: 1586 m; eventDate: 16-23.viii.1971; individualCount: 1; recordedBy: WA Steffan; identifiedBy: K Arakaki; institutionCode: BPBM
- b. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Hana Forest Reserve, stream below base camp, Cheirodendron trigynum; verbatimElevation: 2118 m; eventDate: 10.viii.1974; individualCount: 1; recordedBy: T Parman; identifiedBy: K Arakaki; institutionCode: BPBM
- c. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Haleakala, Paliku, malaise; verbatimElevation: 6500 ft.; eventDate: 27.vi.1975; individualCount: 8; recordedBy: R Burkhardt; identifiedBy: K Arakaki; institutionCode: BPBM

- d. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Haleakala NP, Kaupo Gap, malaise; verbatimElevation: 6100 ft.; eventDate: 3.vii.1975; individualCount: 3; recordedBy: R Burkhart; identifiedBy: K Arakaki; institutionCode: BPBM
- e. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Haleakala, Paliku Cabin, malaise; verbatimElevation: 6400 ft.; eventDate: 4.vii.1975; individualCount: 1; recordedBy: R Burkhart; identifiedBy: K Arakaki; institutionCode: BPBM
- f. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Paliku, crater wall, sweeping veg and ground; verbatimElevation: 6600 ft.; verbatimEventDate: 1.viii.2007; individualCount: 1; recordedBy: KN Magnacca; identifiedBy: PM O'Grady; institutionID: EMEC7356007; institutionCode: EMEC; collectionCode: 07-0716
- g. islandGroup: Hawaiian Islands; island: Lanai; verbatimLocality: Munro Trail, sweeping veg and ground; verbatimElevation: 2800 ft; verbatimEventDate: 30.vii.2007; individualCount: 1; recordedBy: KN Magnacca; identifiedBy: PM O'Grady; institutionID: EMEC7356008; institutionCode: EMEC; collectionCode: 07-0691
- h. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Kaupo Trail, Haleakala National Park, sweeping Lobelia hypoleuca; verbatimElevation: 6100 ft; verbatimEventDate: 2.viii.2007; individualCount: 2; recordedBy: KN Magnacca; identifiedBy: PM O'Grady; institutionID: EMEC7356009; institutionCode: EMEC; collectionCode: 07-0727
- i. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Paliku Cabin, on and under Cheirodendron; verbatimElevation: 6400 ft; verbatimEventDate: 2.viii.2007; individualCount: 3; recordedBy: KN Magnacca; identifiedBy: PM O'Grady; institutionID: EMEC7356010; institutionCode: EMEC; collectionCode: 07-0748
- j. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Kaupo Trail, Haleakala National Park, sweeping veg and ground; verbatimElevation: 5500 ft; verbatimEventDate: 4.viii.2007; individualCount: 6; recordedBy: KN Magnacca; identifiedBy: PM O'Grady; institutionID: EMEC7356011; institutionCode: EMEC; collectionCode: 07-0754

Native status: endemic

Distribution: HAWAIIAN ISLANDS: Lanai, Maui

Notes: Hardy and Delfinado (1980) [original description; illustration of head (anterior), head, (lateral), wing, female abdomen (lateral), male genitalia (left lateral), antenna (lateral)]; Sabrosky (1989) [Australasian and Oceanian Catalog]; Nishida (2002) [Hawaiian Terrestrial Arthropod Checklist]; Evenhuis (2011) [<http://hbs.bishopmuseum.org/aocat/asteiidae.html>, Australasian and Oceanian Catalog, online version].

Asteia sabroskyi Hardy & Delfinado, 1980

Nomenclature: *Asteia sabroskyi* Hardy & Delfinado, 1980: 244

Materials

Holotype:

- a. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Mt. Tantalus; verbatimEventDate: 1.i.1970; individualCount: 1; sex: male; recordedBy: SL Montgomery; institutionCode: BPBM

Paratypes:

- a. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Waiawa; verbatimEventDate: 8.vi.1921; recordedBy: OH Swezey; institutionCode: USNM, BMNH
- b. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Manoa; verbatimEventDate: 12.iii.1945; recordedBy: no collector given; institutionCode: USNM, BMNH
- c. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Mt. Tantalus; verbatimEventDate: 5.v.1956; recordedBy: JW Beardsley; institutionCode: UHEC
- d. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Honolulu; verbatimEventDate: 13.i.1958; recordedBy: CR Joyce; institutionCode: USNM, BMNH
- e. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Honolulu; verbatimEventDate: 8.viii.1958; recordedBy: CR Joyce; institutionCode: USNM, BMNH
- f. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Nuuanu; verbatimEventDate: 26.i.1959; recordedBy: CR Joyce; institutionCode: USNM, BMNH
- g. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Nuuanu; verbatimEventDate: 6.iv.1959; recordedBy: CR Joyce; institutionCode: USNM, BMNH
- h. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Puu Kanehoa; verbatimEventDate: 25.vii-10.viii.1959; recordedBy: JW Beardsley; institutionCode: USNM, BMNH
- i. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Nuuanu; verbatimEventDate: 10.vii.1961; recordedBy: CR Joyce; institutionCode: UHEC
- j. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Mt. Kaala; verbatimEventDate: 30.vi.1963; recordedBy: LH Throckmorton; institutionCode: USNM
- k. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Waimano Trail; verbatimElevation: 400-500m; verbatimEventDate: 5.vii.1963; recordedBy: JL Gressit; institutionCode: BPBM
- l. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: East Makaleha; verbatimEventDate: 7.xii.1969; recordedBy: SL Montgomery; institutionCode: UHEC
- m. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Mt. Tantalus; verbatimEventDate: 1.i.1970; individualCount: 1; sex: female; recordedBy: SL Montgomery; institutionCode: BPBM
- n. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Palikea Gulch; verbatimEventDate: 20.ii.1970; recordedBy: SL Montgomery; institutionCode: UHEC
- o. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Waianae Kai Forest Reserve; verbatimElevation: 1800 ft; verbatimEventDate: 31.v.1970; recordedBy: SL Montgomery; institutionCode: UHEC
- p. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Puu Pane; verbatimEventDate: 18.vi.1970; recordedBy: SL Montgomery; institutionCode: UHEC
- q. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Opaeula; verbatimEventDate: 20.vi-16.vii.1970; recordedBy: SL Montgomery; institutionCode: UHEC
- r. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Puu Kaua; verbatimEventDate: 4-27.viii.1970; recordedBy: SL Montgomery; institutionCode: UHEC
- s. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: East Makaleha; verbatimEventDate: 7.xi.1970; recordedBy: SL Montgomery; institutionCode: UHEC
- t. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Mokuleia; verbatimEventDate: 23.xi.1970; recordedBy: SL Montgomery; institutionCode: UHEC
- u. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Puu Kanehoa; verbatimEventDate: 21.ii.1971; recordedBy: SL Montgomery; institutionCode: UHEC

- v. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Niu; verbatimElevation: 1600 ft; verbatimEventDate: 11.vii.1971; recordedBy: SL Montgomery; institutionCode: UHEC

Other materials:

- a. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Waimea; verbatimEventDate: 26.iv.1944; recordedBy: NLH Krauss; institutionCode: UHEC
- b. islandGroup: Hawaiian Islands; island: Molokai; verbatimLocality: Maunawainui Valley; verbatimEventDate: vii.1952; recordedBy: DE Hardy; institutionCode: UHEC
- c. islandGroup: Hawaiian Islands; island: Kauai; verbatimLocality: Kokee; verbatimElevation: 3600 ft; verbatimEventDate: vii.1953; recordedBy: DE Hardy; institutionCode: UHEC
- d. islandGroup: Hawaiian Islands; island: Kauai; verbatimLocality: Halemanu Valley; verbatimEventDate: viii.1953; recordedBy: DE Hardy; institutionCode: UHEC
- e. islandGroup: Hawaiian Islands; island: Kauai; verbatimLocality: Kawaikoi Stream; verbatimElevation: 3700 ft; verbatimEventDate: viii.1953; recordedBy: DE Hardy; institutionCode: UHEC
- f. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Pauahi; verbatimElevation: 4300 ft; verbatimEventDate: viii.1956; recordedBy: DE Hardy; institutionCode: UHEC
- g. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Mauna Loa Truck Trail; verbatimElevation: 4250 ft; verbatimEventDate: xi.1956; recordedBy: WC Mitchell; institutionCode: UHEC
- h. islandGroup: Hawaiian Islands; island: Kauai; verbatimLocality: Kokee, light trap; eventDate: 29.viii.1959; individualCount: 1; recordedBy: JW Beardsley; institutionCode: BPBM
- i. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Puu Palikea, Metrosideros; verbatimElevation: 2500 ft; eventDate: 15.x.1960; individualCount: 2; recordedBy: TC Maa; identifiedBy: K Arakaki; institutionCode: BPBM
- j. islandGroup: Hawaiian Islands; island: Kauai; verbatimLocality: Mohihi Stream, Kokee; verbatimEventDate: 27.vii.1963; recordedBy: DE Hardy, HT Spieth, LH Throckmorton; institutionCode: UHEC
- k. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Bird Park, Kilauea; verbatimEventDate: 24.vi.1964; recordedBy: LH Throckmorton; institutionCode: UHEC
- l. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Hualalei; verbatimElevation: 2000 ft; verbatimEventDate: 18.viii.1964; recordedBy: DE Hardy; institutionCode: UHEC
- m. islandGroup: Hawaiian Islands; island: Kauai; verbatimLocality: Mohihi Stream, Kokee; verbatimEventDate: 28.viii.1964; recordedBy: DE Hardy, HT Spieth, LH Throckmorton; institutionCode: UHEC
- n. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Kipuka Ki; verbatimEventDate: 8.ix.1964; recordedBy: HT Spieth; institutionCode: UHEC
- o. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Ulukalapua; verbatimEventDate: 26.v.1965; recordedBy: JW Beardsley; institutionCode: UHEC
- p. islandGroup: Hawaiian Islands; island: Kauai; verbatimLocality: Alakai, Kokee; verbatimElevation: 4000 ft; verbatimEventDate: 14.ix.1965; recordedBy: CM Yoshimoto; institutionCode: UHEC
- q. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Hualalai, N slope kipuka; verbatimElevation: 5000 ft; eventDate: 7.x.1968; individualCount: 1; recordedBy: DE Hardy; identifiedBy: K Arakaki; institutionCode: BPBM

- r. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Kaupo Gap; verbatimElevation: 4800 ft; verbatimEventDate: 21.iv.1971; recordedBy: SL Montgomery; institutionCode: UHEC
- s. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: North Kona, Puuwaawaa; verbatimElevation: 3700 ft; verbatimEventDate: no date given; recordedBy: WM Giffard; institutionCode: UHEC
- t. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Kipahulu Valley, nr. Puu Ahuula; verbatimElevation: 300 m; eventDate: 23.vii.1980; individualCount: 1; recordedBy: WC Gagne; collectionID: 1980.322; institutionCode: BPBM
- u. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Kulouou For. Res., Euphorbia celastroides; verbatimElevation: 609 m; eventDate: 16.xi.1980; individualCount: 1; recordedBy: WC Gagne; collectionID: 1980.545; institutionCode: BPBM
- v. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Lualualei, Halona Valley, at MV light; verbatimElevation: 1420 ft; eventDate: 19-20.i.1996; individualCount: 1; recordedBy: GM Nishida; institutionCode: BPBM
- w. islandGroup: Hawaiian Islands; island: Oahu; verbatimLocality: Manoa Cliff Trail, in Freycinetia axil; verbatimElevation: 1800 ft; verbatimEventDate: 25.ii.2007; individualCount: 1; recordedBy: KN Magnacca; identifiedBy: PM O'Grady; institutionID: EMEC7356012; institutionCode: ECEM; collectionCode: 07-0176
- x. islandGroup: Hawaiian Islands; island: Maui; verbatimLocality: Puu Kukui, Kahanaiki Gulch, sweeping Cyrtandra; verbatimElevation: 2100 ft; verbatimEventDate: 7.viii.2007; individualCount: 1; recordedBy: KN Magnacca; identifiedBy: PM O'Grady; institutionID: EMEC7356013; institutionCode: ECEM; collectionCode: 07-0819
- y. islandGroup: Hawaiian Islands; island: Hawaii; verbatimLocality: Hawaii Volcanoes National Park, Kipuka Puaulu; verbatimEventDate: 1.viii.2010; individualCount: 1; recordedBy: PM O'Grady, RT Lapoint, GM Bennett, NA Pantoja; identifiedBy: PM O'Grady; institutionID: EMEC7356014; institutionCode: ECEM; collectionCode: 610.4

Feeds on: This species has been reared from rotting stems and bark of several native Hawaiian plant species, including *Pisonia*, *Charpentiera*, *Urera* and *Hibiscadelphus*.

Native status: endemic

Distribution: HAWAIIAN ISLANDS: Kauai, Oahu, Molokai, Maui, Hawaii

Notes: Hardy and Delfinado (1980) [original description; illustration of male genitalia (lateral, Oahu), male genitalia (lateral, Hawaii), egg]; Sabrosky (1989) [Australasian and Oceanian Catalog]; Nishida (2002) [Hawaiian Terrestrial Arthropod Checklist]; Evenhuis (2011) [<http://hbs.bishopmuseum.org/aocat/asteiidae.html>], Australasian and Oceanian Catalog, online version].

Discussion

These revised numbers of single island endemics significantly change how our interpretations of diversification may be occurring, particularly in smaller, more recent radiations like *Asteia*. The prevailing dogma is that a population of one species colonizes a neighbor island, becomes reproductively isolated and, over time, diverges in allopatry,

forming a distinct sister species. There are many examples of such divergence in the Hawaiian *Drosophila* (e.g., Bonacum et al. 2005). Taxa endemic to Maui Nui (the islands of Maui, Molokai, Lanai and Kahoolawae) often display a slightly different pattern due to the recent historical connections present between these islands in periods of low sea stands (Price and Elliott-Fisk 2004). If a species is present on more than one island, it is often the case that these islands are in the Maui Nui group. This is the case with two of the seven new island records we report in this paper. There is little evidence concerning the dispersal abilities of these taxa or the potential mechanism for inter-island transport. There are no flightless or brachypterous *Asteia* so they may be able to fly from island to island. They may also be blown from one island to another, as has been suggested for several other groups of Hawaiian Diptera (Nitta and O'Grady 2008, O'Grady et al. 2009, Zimmerman 1948). Additional work is clearly needed to better understand dispersal ability in various groups of Hawaiian arthropods.

Multiple lineages of broadly overlapping species suggest another process may be acting in groups such as *Dicranomyia* (Goodman and O'Grady 2013, Nitta and O'Grady 2008) and *Asteia*. In these groups divergence may take place on smaller geographic scales (e.g., within an island) or be driven by adaptation to different ecological niches. Two species of Hawaiian *Asteia* have been reared from a number of native Hawaiian tree species (Table 2), suggesting an ecological role for divergence within this group. While some taxa (e.g., *A. nudiseta* on *Suttonia* = *Myrsine*) have label data that indicate some association with a specific plant, we did not include them in Table 2 unless the author stated they were reared.

Table 2.

Rearing records for endemic Hawaiian *Asteia*. Tabular summary of rearing records for Hawaiian *Asteia* (Hardy and Delfinado 1980).

Species	Island	Record
<i>A.montgomeryi</i>	Hawaii	<i>Erythrina sandwicensis</i> , rotting stems
<i>A.sabroskyi</i>	Oahu	<i>Pisonia</i> sp., rotting stem and bark
	Oahu	<i>Urera</i> sp., rotting stem
	Oahu	<i>Charpentiera</i> sp., rotting stem
	Oahu	<i>Hibiscadelphus</i> sp., rotting bark
	Maui	<i>Pisonia</i> sp., rotting stem

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Author contributions

O'Grady and Magnacca collected the new material for this paper and transcribed the label data and literature records from older material. O'Grady determined the material present in the UC Berkeley collection. O'Grady and Magnacca wrote the paper.

References

- Bonacum J, O'Grady P, Kambsellis M, DeSalle R (2005) Phylogeny and age of diversification of the planitibia species group of the Hawaiian *Drosophila*. Molecular Phylogenetics and Evolution 37 (1): 73-82. DOI: [10.1016/j.ympev.2005.03.008](https://doi.org/10.1016/j.ympev.2005.03.008)
- Evenhuis N (2008) Hawaii's Diptera biodiversity. In: Pape T, Bickel D, Meier R (Eds) Diptera diversity: status, challenges and tools. E.J. Brill, Leiden.
- Evenhuis N (2011) Family Asteiidae. In: Evenhuis N (Ed.) Catalog of the Diptera of the Australasian and Oceanian Regions. (online version). URL: <http://hbs.bishopmuseum.org/aocat/hybotidae.html>
- Evenhuis N, Eldredge L (Ed.) (2004) Natural History of Nihoa and Necker Islands. 1. Bishop Museum Press, Honolulu, 220 pp.
- Goodman KR, O'Grady P (2013) Molecular Phylogeny and Biogeography of the Hawaiian Craneflies *Dicranomyia* (Diptera: Limoniidae). PLoS ONE 8 (9): e73019. DOI: [10.1371/journal.pone.0073019](https://doi.org/10.1371/journal.pone.0073019)
- Grimshaw P (1901) Diptera. Fauna Hawaiensis 3: 1-77.
- Hardy D, Delfinado M (1980) Diptera, Cyclorrhapha III. Insects of Hawaii 13: 1-451.
- Nishida G (2002) Hawaiian Terrestrial Arthropod Checklist. Bishop Museum Technical Report 22: 1-313.
- Nitta J, O'Grady P (2008) Mitochondrial phylogeny of the endemic Hawaiian craneflies (Diptera, Limoniidae, *Dicranomyia*): Implications for biogeography and species formation. Molecular Phylogenetics and Evolution 46 (3): 1182-1190. DOI: [10.1016/j.ympev.2007.12.021](https://doi.org/10.1016/j.ympev.2007.12.021)
- O'Grady P, Magnacca K, Lapoint R (2009) *Drosophila*. In: Gillespie R, Clague D (Eds) Encyclopedia of Islands. University of California Press
- Price J, Elliott-Fisk D (2004) Topographic history of the Maui Nui complex, Hawai'i, and its implications for biogeography. Pacific Science 58 (1): 27-45.
- Sabrosky C (1947) A new species of the dipterous family Asteiidae from Hawaii. Proceedings of the Hawaiian Entomological Society 13: 55-57.
- Sabrosky C (1956) Additions to the knowledge of Old World Asteiidae (Diptera). Revue fr. Ent. 23: 216-243.
- Sabrosky C (1957) Synopsis of the New World Species of the dipterous family Asteiidae. Ann. Ent. Soc. Am 50: 43-61.
- Sabrosky C (1987) Asteiidae. Manual of Nearctic Diptera. 2. Agriculture Canada, Ottawa, 4 pp.

- Sabrosky C (1989) Family Asteiidae. In: Evenhuis N (Ed.) Catalog of the Diptera of the Australasian and Oceanian Regions. Bishop Museum Press, Honolulu, 1155 pp.
- Sharp D (Eds) (1899) Fauna Hawaiiensis or the zoology of the Sandwich (Hawaiian) Isles: being results of the explorations instituted by the Joint Committee appointed by the Royal Society of London for promoting natural knowledge and the British Association for the Advancement of Science and carried on with the assistance of those bodies and of the Trustees of the Bernice Pauahi Bishop Museum at Honolulu. Cambridge University Press, 791 pp.
- Zimmerman EC (Eds) (1948) Insects of Hawaii. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. University of Hawaii Press, Honolulu, 254 pp.